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MIDLAND STANDARD ENGINEERING & TESTING, INC.

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March 14, 2016

Mr. David Kraft, P.E.
Hey & Associates, Inc.
26575 W. Commerce Drive, Suite 601
Volo, Illinois 60073

Re: Soil Exploration and Analysis
Culvert Replacement
Pulaski Memorial Drive
Lake County, Illinois
MSET File No. 16225

Dear Mr. Kraft:

Midland Standard Engineering & Testing, Inc. (MSET) has conducted a subsurface exploration and laboratory analysis for the above referenced project.

Scope and Purpose

The purpose of this exploration and analysis was to determine the various soil profile components, the engineering characteristics of the materials, and to provide criteria for use by the design engineers in preparing project plans for the culvert replacement design. This report does not address environmental issues at the site. The scope of this exploration included a geological reconnaissance of the site, subsurface exploration, soil testing, and an engineering analysis and evaluation of the material encountered.

General

The exploration and analysis of the subsurface soil conditions reported herein are considered in sufficient detail and scope to form a reasonable basis for final design. This report has been prepared for the exclusive use and specific application to the proposed project.

The recommendations submitted are based on the available soil information and the preliminary site plans furnished to us. Any revision in the plans for the proposed culvert replacement from those enumerated in this report should be brought to the attention of the Soils Engineer so that he may determine if changes in the recommendations are required. If deviations from the noted subsurface conditions are encountered during construction, they should also be brought to the attention of the Soils Engineer.

The Soils Engineer warrants that the findings, recommendations, specifications or professional advice contained herein have been promulgated after being prepared in accordance with generally accepted professional engineering practice in the fields of foundation engineering, soil mechanics and engineering geology. No other warranties are implied or expressed.

After the plans are more complete, it is recommended the Soils Engineer be provided the opportunity to review the final design and specifications, in order that the soil recommendations may be properly interpreted and implemented. At that time, it may be necessary to submit supplementary recommendations.

PROJECT DESCRIPTION

Project and Site Description

The project consists of the replacement of an existing 30" cross culvert/storm sewer that carries storm water flow under Pulaski Memorial Drive. The crossing is located on County Highway 78-Pulaski Memorial Drive approximately 600 to 700 feet east of US Highway 41. Pulaski Memorial Drive goes over US 41 and a railroad line and there is a considerable embankment at the culvert crossing. Pavement grade at the crossing is roughly 711 with the existing storm pipe invert at 683.5, a difference of 27.5 feet.

Preliminary design plans call for removing the existing 36" pipe and replacing with a 48" to 60" new pipe using pipe consumption methods. In this case the larger new pipe surrounds the old pipe as it is removed. Additional work on the project involves the removal of a 96" diameter corrugated metal pipe cattle crossing the lies about 150 feet to the east.

FIELD EXPLORATION

General

The field investigation to determine the engineering characteristics of the subsurface material included a making three (3) soil borings for the proposed work. The soil borings were drilled to depths of fifteen (15) to thirty (30) feet below the ground surface. Boring B-1 was located at the north end of the pipe replacement for a possible jacking pit. Boring B-2 was located on the south shoulder of Pulaski Drive along the pipe alignment. Boring B-3 was located on the north road shoulder near the cattle crossing alignment.

Reference the attached Boring Location Diagrams for details of the boring locations relative to the existing conditions. The borings were staked in the field by MSET and the ground surface elevation at each boring was determined relative to Google Earth mapping.

Drilling Equipment

The soil brings were drilled using a track mounted Geoprobe® 7822 drill rig equipped with a rotary head. The holes were advanced using hollow stem augers. The drill rig was equipped with an automatic drop hammer for standard penetration testing.

Sampling and Standard Penetration Test Procedures

Representative samples were obtained by the use of split-spoon sampling procedures in accordance with A.S.T.M. Procedure D-1586.

During the split-spoon sampling procedures, a standard penetration test was performed in accordance with current A.S.T.M. D-1586 Procedures. At sampling intervals, advancement of the boring was stopped and all loose material removed from the borehole. The sampler was than lowered into the hole and seated in undisturbed soil by pushing or tapping, taking suitable precautions that the rods were reasonably tight. The sampling spoon was then advanced by driving with an automatic drop hammer. During the sampling procedure, the standard penetration value (N) of the soil was determined. The standard penetration value (N) is defined as the number of blows of a one hundred-forty pound (140 lb) hammer required to advance the spoon sampler one foot (12") into the soil.

The results of the standard penetration tests indicate the relative density and comparative consistency of the soils and thereby provide a basis for estimating the relative strength and compressibility of the soil profile components. The results of standard penetration tests can be found on the boring logs, which are attached.

Strength Tests

During the field borings operations, samples of the predominately cohesive soil from the split-spoon sampling device were tested using a calibrated soil penetrometer to aid in determining the strength of the soil. Consideration must be given to the manner in which the values of the unconfined compressive strengths were obtained. Split-spoon sampling techniques provided a representative, but somewhat disturbed, soil sample.

Water Level Measurements

Water level observations were made during and after the boring operations and are noted on the boring logs presented herewith. In relatively previous soils, such as sandy soils, the indicated elevations are considered reliable groundwater levels. In relatively impervious soils, the accurate determination of the groundwater elevation may not be possible, even after several days of observation. Seasonal variations, temperatures, and recent rainfall conditions may influence the levels of the groundwater table, and volumes of water depend on the permeability of the soils.

LABORATORY TESTING

Scope

A supplemental laboratory-testing program was conducted to ascertain the pertinent engineering characteristics for the subsurface materials necessary in analyzing the behavior of the proposed construction. The soils laboratory work was preformed in accordance with applicable A.S.T.M. standards. The laboratory-testing program included visual classification and moisture content determinations on all split-spoon samples. All cohesive soil samples obtained from the split-spoon were also tested for unconfined compressive strength (Qu). The results of this laboratory testing are presented on the attached boring logs.

SUBSURFACE CONDITIONS

Subsurface Conditions

The subsurface soil profile encountered in the borings located on the shoulder of the road, B-2 and B-3 encountered 18.5 and 8.5 feet of embankment FILL, respectively. This FILL was densely compacted Silty CLAY FILL for the most part with Sandy CLAY some cobbles at a depth of 6.0 to 8.5 feet at boring B-3. Moisture contents in the FILL ranged from 13 to 19 percent. Silty CLAY FILL was also encountered at B-1, extending to a depth of 1.5 feet.

The natural soil profile underlying the FILL is composed of very stiff to hard, brown to grey Silty CLAY glacial till at boring B-1 and B-2. Boring B-3, located for the cattle crossing removal, encountered medium dense SILT, slightly dense Sandy SILT, and very stiff Silty CLAY to Clayey SILT beneath embankment FILL, from a depth of 8.5 to 15 feet.

Ground water level measurements were made during and immediately after the drilling operations. Ground water measured at boring B-1 was 3.25 feet below the ground surface during drilling and was dry with the hole caved at 10.8 feet at completion. Ground was not encountered in the all clay soil profile at boring B-2 during the drilling operations. At boring B-3, the ground water was at depths of 11.0' during drilling, and at 14.4 feet at completion of the work. Ground water can be expected below elevation 690 +/-

FINDINGS AND RECOMMENDATIONS

Pipe Replacement

Current plans call for trenchless pipe replacement using consumption methods utilizing an oversized, 60" diameter pipe. For this type of installation and pipe size, typically pipe jacking or tunneling procedures are used. The rough pipe elevation will be from elevation 682 to 688, and very stiff to hard Silty CLAY was encountered in borings B-1 and B-2 at this level. This soil type, while relatively stiff, should contain few cobbles and boulders, and is expected to hold its shape well while excavating to advance the pipe. Both tunneling and pipe jacking methods require the existing pipe to be removed by workers, one section at a time as the new pipe advances. The tunneling method generally allows for more alignment correction, by adjusting the tunnel shield as work progresses. Invert for the new over sized pipe is usually obtained by placing concrete in the bottom of the pipe to the flow line level. A slightly over sized excavation and pipe lubrication is typically used to help advance the pipe. When the new pipe string is in place, the contact annular space, pipe to soil, should be pressure grouted to fill any voids and prevent ground settlement.

A jacking or access pit will be excavated on the north side of the road. Because of the road embankment configuration and the recent ditch work on the south side of the road, a receiving pit is not required. The flow of the storm sewer will be temporarily diverted during the pipe replacement work.

Cattle Crossing Abandonment

On Pulaski Drive, just to the east of the storm sewer replacement work, a 96" diameter cattle crossing culvert is scheduled to be removed or abandoned. The cattle crossing invert is 693.73 north, and 693.98 south, with the centerline of the road at elevation 703.6 +/-. There is roughly two feet of cover/pavement section on the pipe. If the culvert is removed by excavation, work to backfill the excavation and support the road will require careful attention to detail as outlined in 'Structure Backfill' below. In this case, we would expect that traffic would be staged, allowing work on half the alignment at a time, using temporary sheet pile or soldier pile bracing at the road centerline. Boring B-3, made for this crossing encountered very stiff to hard Silty CLAY embankment fill that can stand nearly vertical during the removal and backfill work, however note the requirement of stepping each lift of backfill into the existing soil.

The crossing culvert can also be abandoned in place by properly filling the culvert with suitable material. The culvert can be filled with flowable, low strength pumped concrete/grout. Cellular concrete grout is commonly used for this type of work because of its high air content/flowability. It is important in this type of work to inspect for voids and pressure grout from the road surface as necessary to eliminate any voids at the top of the culvert and under the pavement section.

Structure Backfill

If the culvert is excavated and removed, backfill should be stepped into the existing embankment fill, placed in lifts, compacted to the required density. All excavations should be backfilled in accordance with Article 502.10 'Backfilling', in 'Excavation for Structures', Section 502 of the Standard Specifications for Road and Bridge Construction.

CONSTRUCTION CONSIDERATIONS

Construction Excavation Support

Excavations will be required for the pipe jacking/access pit and will be required if the cattle crossing is removed. Note that OSHA requirements dictate the use of sloping back or shoring and bracing of the excavation during installation. All work should be done in accordance with OSHA and local requirements.

If the cattle crossing is removed and backfilled, excavations will require sloping back or benching of side cut or a Temporary Soil Retention System for the construction period. Construction staging for this work may require excavation bracing for traffic lanes. The contractor is responsible for the design of all excavation support systems. Soil Strength Parameters that can be used for a Temporary Soil Retention System design for deeper excavations are provided in Table 1, 'Soil Strength Parameters'. IDOT Temporary Sheet Pile Design Guides cannot be used because of the existing hard CLAY with unconfined compressive strengths greater than 4.5 tons per square foot.

Closure

The recommendations presented herein are based on the information available at the time of this writing. After the plans and specifications are more complete, we welcome the opportunity to review them with respect to prevailing soil and ground water conditions.

At that time, it may be necessary to conduct further analysis and submit supplementary recommendations. If the plans are changed with respect to the location of the pipe or structures, the soils information must be reviewed to determine whether it is pertinent to the new plans.

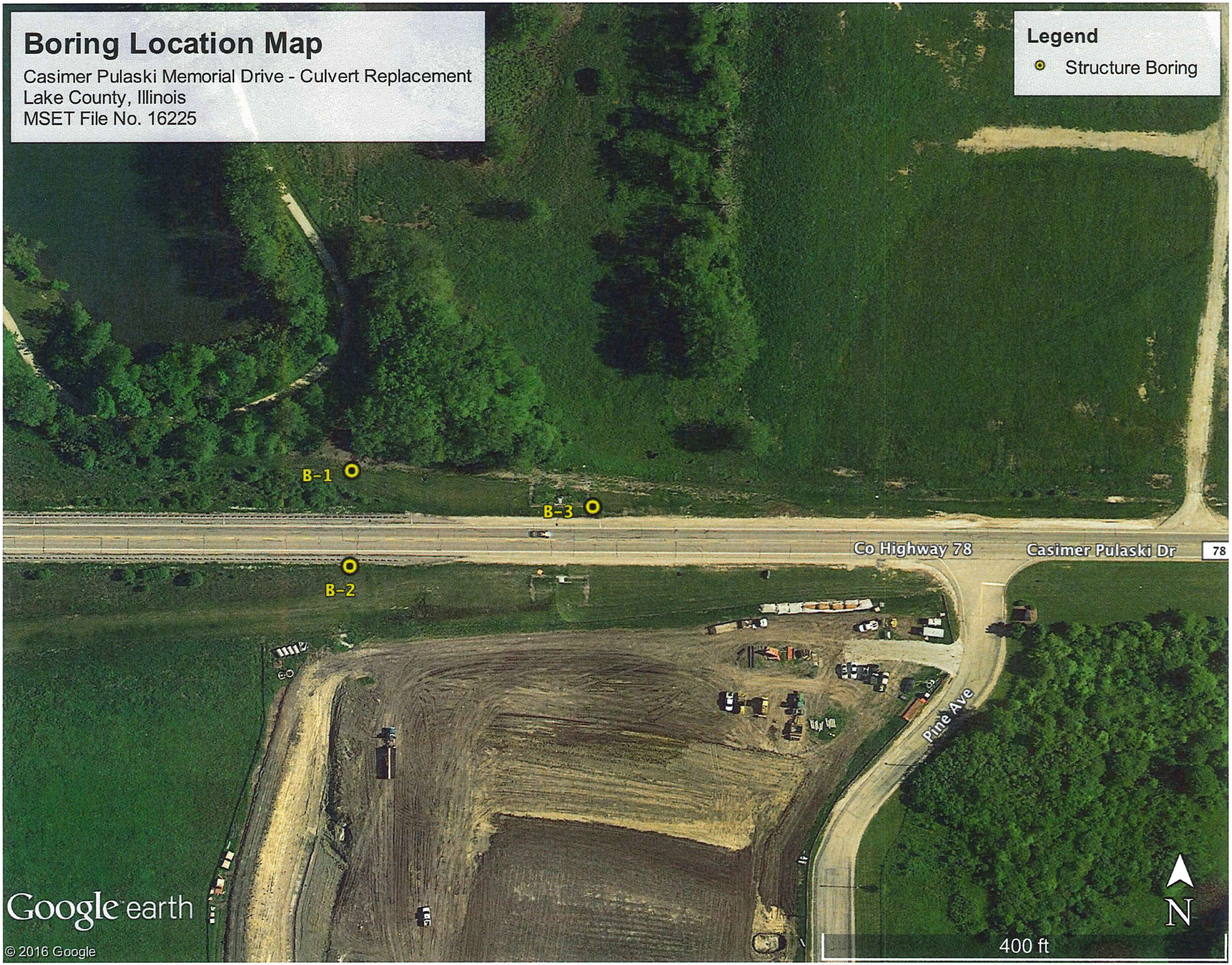
Thank you for the opportunity to provide our services to you on this project. If you have any questions or require further analysis, do not hesitate to contact us.

Sincerely,
MIDLAND STANDARD ENGINEERING & TESTING, INC.

William J. Wyzgala, P. E.
Project Engineer

Attachments:

Boring Location Diagram
Boring Logs B-1, B-2, and B-3
General Notes


Boring Location Map
Casimer Pulaski Memorial Drive - Culvert Replacement
Lake County, Illinois
MSET File No. 16225
Legend
Structure Boring
B-1
B-3
B-2
Co Highway 78
Casimer Pulaski Dr
78
Pine Ave
Google earth
© 2016 Google
N
400 ft

MSET PROJECT NO.: 16225	LOG OF BORING NO. B-1	Page 1 of 1

PROJECT: **Pulaski Memorial Drive** SITE LOCATION: **North Chicago, Illinois**

BORING LOCATION: **N. End of Sewer Replacement** CLIENT: **Hey and Associates, Inc.**

DEPTH (feet)	SOIL TYPE	Material Description	Elevation	SAMPLE TYPE/ INTERVAL	SAMPLE NO.	SAMPLE N-VALUE Blows per ft.	TESTS Wc%	TESTS Dry Unit Weight, pcf	TESTS Unconfined Compressive Strength, tsf	REMARKS
0		TOPSOIL - Black Silty CLAY, trace Sand, CL (6")	692.3							
			691.8							
		FILL - Brown, Grey and Black Silty CLAY, little to some Sand, trace Gravel, CL	690.8	SS	1	6	23	94	1.75	
3		Brown and Grey Silty CLAY, trace Sand, CL, stiff								
		Sand seam at 3.25', wet	688.8	SS	2	5	17	111	2.79	
		Brown Silty CLAY, trace Sand, trace Gravel, CL, very stiff	686.8							
6		Grey Silty CLAY, trace Sand, trace Gravel, CL, hard to very stiff		SS	3	14	15	113	6.25	
9				SS	4	18	15	115	5.43	
12				SS	5	20	16	113	6.56	
				SS	6	10	19	103	3.57	
		End of Boring at 15'	677.3							

WATER LEVEL OBSERVATIONS, ft.
DURING DRILLING: 3.25'
IMMEDIATELY AFTER DRILLING: Dry
DELAYED READING AFTER

MSET

BORING STARTED: 3/4/16
BORING COMPLETED: 3/4/16
LOGGED BY: GPF
BORING METHOD: HSA

MSET PROJECT NO.: 16225	LOG OF BORING NO. B-2	Page 1 of 1
PROJECT: Pulaski Memorial Drive	SITE LOCATION: North Chicago, Illinois	
BORING LOCATION: S. Road Shoulder, Sewer Alignment	CLIENT: Hey and Associates, Inc.	

DEPTH (feet)	SOIL TYPE	Material Description	Elevation	SAMPLE TYPE/ INTERVAL	SAMPLE NO.	SAMPLE N-VALUE Blows per ft.	TESTS Wc%	TESTS Dry Unit Weight, pcf	TESTS Unconfined Compressive Strength, tsf	REMARKS
0		Bituminous Concrete Pavement (3")	711.7							
		BASE COURSE - RAP over Brown SAND (2.5")	711.5 / 711.2	SS	1	7	14		4.5 (Qp)	
		FILL - Brown and Black to Grey Silty CLAY, little Sand, trace to little Gravel, CL, hard								
4				SS	2	7	16		4.5+ (Qp)	
		moist		SS	3	15	14	114	6.60	
8		FILL - Brown and Grey, trace Black Silty CLAY, little Sand, trace Gravel, CL very stiff to hard	703.2	SS	4	10	17	109	3.80	
				SS	5	18	14	116	4.53	
12				SS	6	19	12	115	6.01	
16		FILL - Grey and Black Silty CLAY, little to some Sand, little Gravel, trace Wood, trace RAP, CL-SC hard	695.7	SS	7	24	16	108	6.13	
		Grey Silty CLAY, trace Sand, trace Gravel, trace Roots, CL, hard to very stiff	693.2	SS	8	12	30	83	4.35	
20				SS	9	7	20	103	2.13	
24		Grey Silty CLAY, trace Sand, trace Gravel, Fe stains, CL, hard to very stiff	688.2	SS	10	19	16	111	7.53	
				SS	11	14	17	113	5.24	
28				SS	12	12	16	112	3.22	
		End of Boring at 30'	682.2							

WATER LEVEL OBSERVATIONS, ft.
DURING DRILLING: None
IMMEDIATELY AFTER DRILLING: Dry
DELAYED READING AFTER

MSET

BORING STARTED: 3/4/16
BORING COMPLETED: 3/4/16
LOGGED BY: GPF
BORING METHOD: HSA

MSET PROJECT NO.: 16225	LOG OF BORING NO. B-3	Page 1 of 1

PROJECT: **Pulaski Memorial Drive** SITE LOCATION: **North Chicago, Illinois**

BORING LOCATION: **South Shoulder, Cattle Crossing** CLIENT: **Hey and Associates, Inc.**

DEPTH (feet)	SOIL TYPE	Material Description	Elevation	SAMPLE TYPE/ INTERVAL	SAMPLE NO.	SAMPLE N-VALUE Blows per ft.	TESTS Wc%	TESTS Dry Unit Weight, pcf	TESTS Unconfined Compressive Strength, tsf	REMARKS
0		FILL - Black and Grey Silty CLAY, trace Sand, trace Gravel, CL very stiff to hard	701.7							
				SS	1	11	15	109	3.10	
		to Brown, Grey and Black								
3										
				SS	2	24	13	114	6.51	
6		FILL - Black and Grey Sandy CLAY, little Gravel, SC	695.7	SS	3	30/ 6"	15			
		Cobbles at 7.5'								
9		Brown and Grey SILT, moist, ML, medium dense	693.2	SS	4	9	18	105	1.38	
		Brown Sandy Silt, SM, slightly dense	691.2							
				SS	5A	8	21			
12		Grey Silty CLAY to Clayey SILT, trace Sand, CL-ML, moist, very stiff	689.7	SS	5B	10	20			
				SS	6	9	22		3.41	
		End of Boring at 15'	686.7							

WATER LEVEL OBSERVATIONS, ft.
DURING DRILLING: 11.0'
IMMEDIATELY AFTER DRILLING: 14.4'
DELAYED READING AFTER

MSET

BORING STARTED: 3/4/16
BORING COMPLETED: 3/4/16
LOGGED BY: GPF
BORING METHOD: HSA

GENERAL NOTES

PARTICLE SIZE DESCRIPTION & TERMINOLOGY

Coarse Grained or Granular Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine Grained soils have less than 50% of their dry weight retained on a #200 sieve; they are described as: clays or clayey silts if they are cohesive and silts if they are non-cohesive. In addition to gradation, granular soils are defined on the basis of their relative in-place density and the fine grained soils on the basis of their strength or consistency and their plasticity.

Major Component of Sample	Size Range
Boulders	Over 8 in. (200 mm)
Cobbles	8 inches to 3 inches (200 mm to 75mm)
Gravel	3 inches to #4 sieve (75mm to 4.75mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt	Passing #200 sieve (0.075mm to 0.002mm)
Clay	Smaller than 0.002mm

Descriptive Term of Components Also Present in Sample	Approximate Quantity (Percent)
Trace	1 - 9
Little	10 - 19
Some	20 - 34
And	35 - 50

RELATIVE DENSITY AND CONSISTENCY CLASSIFICATION

GRANULAR SOILS

DENSITY CLASSIFICATION	APPROXIMATE RANGE OF N *
Very Loose	0 - 3
Slightly Dense	4 - 9
Medium Dense	10 - 29
Dense	30 - 49
Very Dense	50 - 80
Extremely Dense	80 +

COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH, Qu - TSF	APPROXIMATE RANGE OF N *
Very Soft	0.25	0 - 2
Soft	0.25 - 0.49	3 - 4
Firm	0.50 - 0.99	5 - 8
Stiff	1.00 - 1.99	9 - 15
Very Stiff	2.00 - 3.99	16 - 30
Hard	4.00 - 8.00	31 - 50
Very Hard	8.00 +	Over 50

* STANDARD PENETRATION TEST (ASTM D1586) - A 2.0" outside-diameter, split barrel sampler is driven into undisturbed soil by means of a 140 pound weight falling freely through a vertical distance of 30 inches. The sampler is normally driven 3 successive 6 inch increments. The total number of blows required for the final 12 inches of penetration is the Standard Penetration Resistance (N).